Physics students' strategies for learning: an investigation

Gary D. Petersen and R. Kelly Michael, EdD

Department of Physics, Angelo State University, San Angelo, Texas

Introduction

Learning new material may be difficult for students. This is especially so for students in upper level, physics courses where integration of a variety of learning strategies may be needed to gain understanding of new material. In many cases students will often employ previously learned study techniques to engage the new material.

Study strategies are forms of active learning performed by students to encode learning material. The ways certain students study and learn is somewhat of an individual decision, but some strategies may be more beneficial than others. Examples of strategies include doing advanced reading, studying a variety of information, and explaining what they learned to their peers (Kober, 2015, p.108).

Instructors can play a pivotal role encouraging strategies of learning or techniques of adaptation to course content (Kober, 2015). One issue facing faculty though is they may not express the breadth of ways students may approach learning and oftentimes may not recognize the specific strategies often employed by more successful students.

Purpose Statement

The purpose of this research project is to investigate which study methods are predominately employed by undergraduate physics students during advanced physics courses.

A second reason to perform this study relates to the mission of the American Association for the Advancement of Science: "advance science, engineering and innovation throughout the world for the benefit of all people" (http://www.aaas.org/about/mission-and-history).

Literature Review

What Learning Strategies Work and Don't Work in Physics Education

- Overly detailed explanations are not useful (Redish & Steinberg, 1999),
- Active student involvement is important to learning physics (Zlateva & Tsankova, 2009).
- Students feel teachers should provide questions and then guide students to solve them (Stefan, 2010).
- Teachers feel students should "self-adjust his or her learning process." (Stefan, 2010, p. 200).
- Learning how to switch from one viewpoint to another has shown benefits in learning (Bollen, Van Kampen, Baily, & De Cock, 2016).
- Mistakes resulting in contradictory answers when using the different approaches may be mitigated by discussing them (Bollen, Van Kampen, Baily, & De Cock, 2016).
- Stang, Barker, Perez, Ives, and Roll (2016) found no significant differences when assessing the learning technique of pre-reading for an inquiry-based engagement physics activity for an introductory physics' course.
- Results are mixed regarding peer teaching. Peer tutoring has been shown to not significantly help (Dioso-Henson, 2012) while learning assistants on the other hand have been helpful in increasing understanding of physics concepts (White, Van Dusen, & Roualdes, 2016).

A Solution

Use efficacious strategies: (Dunlosky, Rawson, March, Nathan & Willingham, 2013)

- **High utility assessments** (1) Practice testing and (2) distributed practice benefit learners of different ages and abilities and have been shown to boost students' performance across many criterion tasks and even in educational contexts.
- **Moderate utility assessments** (3) Elaborative interrogation, (4) self-explanation, and (5) interleaved practice techniques do generalize across some variables, yet despite their promise, they fell short of a high utility assessment because the evidence for their efficacy is limited.
- **Low utility assessments** (6) Summarization, (7) highlighting, (8) the keyword mnemonic, (9) imagery use for text learning, and (10) rereading techniques were rated as low utility as data does not support or there is not enough data about their efficacy or usefulness.

Methods

Subjects: Individuals enrolled in advanced physics classes at regional Texas university, i.e. 3000 and 4000 level courses (n = 18)
Recruitment procedure: flyers, direct pleas to students, and professors of advanced physics classes.
Survey Procedure: Participants were directed to a Qualtrics™ survey link to complete the learning strategies survey.
Measurement Procedure: Data processing tools within the Qualtrics program used to analyze collected data.

Measurement of Outcomes

Demographics were collected, including the average grade in physics classes and the number of upper-level physics classes taken.

The following are representative of the study strategy questions asked. See Results section for a complete list of those questions. Each participant could choose more than one study strategy.

1. I **take notes** when reading to learn
2. I use **rehearsal / rote memorization** to learn material
3. I **read** to learn material
4. I **re-read** to learn material
5. I **highlight** and **underline** in textbooks and other materials
6. I use **concept mapping** or **imagery** (creating mental images as reminders of material) as a way of learning

Results

Q7 - What is your Overall - Grade Point Average (GPA)

#	Answer	%	Count
1	A	33.33	6
2	B	44.44	8
3	C	22.22	4
4	D	0	0
5	F	0	0
	Total	100	18

Q8 - What is your Advanced Physics Courses - Grade

#	Answer	%	Count
1	A	38.89	7
2	B	33.33	6
3	C	27.78	5
4	D	0	0
5	F	0	0
	Total	100	18

Question #9	Answer	%	Count
1	I take notes when reading to learn	33.33%	6
2	I use rehearsal / rote memorization to learn material	33.33%	6
3	I read to learn material	44.44%	8
4	I re-read to learn material	50.00%	9
5	I highlight and underline in textbooks and other materials	16.67%	3
6	I use concept mapping or imagery (creating mental images as reminders of material) as a way of learning	27.78%	5
7	I summarize material as a way to learn	27.78%	5
8	I listen to others talk about course material as a way to learn	50.00%	9
9	I use acronyms or mnemonics – use of key words and mnemonics (letter sequences, sayings, etc.) - as reminders of course material as a way to learn	5.56%	1
10	I ask myself "why" questions to make connections between new and old material as a way of learning	55.56%	10
11	I provide my own explanations for problems as a way to learn material	44.44%	8
12	I do self-testing, like flashcards, sample problems, sample tests, to learn	33.33%	6
13	I study material over a number of relatively short sessions to learn	27.78%	5
14	I use select spaces or areas conducive to learning	38.89%	7
15	I use reflection as part of my learning such as actively writing or thinking about material to make mental connections	33.33%	6
16	Other (please type other strategies you use in the box provided)	11.11%	2

Comparing Strategies of Novice Students to More Experienced

Question->	1	2	3 *	4 *	5	6	7	8 *	9	10 *	11 *	12	13	14	15	16
# of classes taken																
0																
1	1	1	1	1	0	1	1	1	0	1	1	1	0	0	1	1
2	0	1	1	1	0	0	1	1	0	1	1	1	1	0	0	0
3	1	1	0	1	0	0	0	2	0	2	1	1	1	1	1	0
Sub Total	2	3	2	3	0	1	2	4	0	4	3	3	2	1	2	1
Percent	33	50	33	50	0	17	33	67	0	67	50	50	33	17	33	17
4	1	1	1	2	2	1	0	2	1	2	2	1	0	3	4	1
5	3	0	2	2	1	2	2	1	0	2	2	1	2	2	0	0
6	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0
7	0	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0
8																
9	0	0	1	1	0	0	0	0	1	0	1	1	0	0	1	0
10																
Sub Total	4	3	6	6	3	4	3	5	1	5	5	3	3	6	4	1
Percent	33	25	50	50	25	33	25	42	8	42	42	25	25	50	33	17
Difference	0	-25	17	0	25	16	-8	-25	8	-25	-8	-25	-8	33	0	0

When comparing the study strategies of students who have completed three or fewer classes to those of more experienced students, some trends emerge. From questions 2, 8, 10 and 12, we find that experienced students use less rote memorization, listening to others, asking themselves why, and self-testing with sample problems. From questions 5 and 14, we find that more experienced students are more likely to highlight and to care where they study.

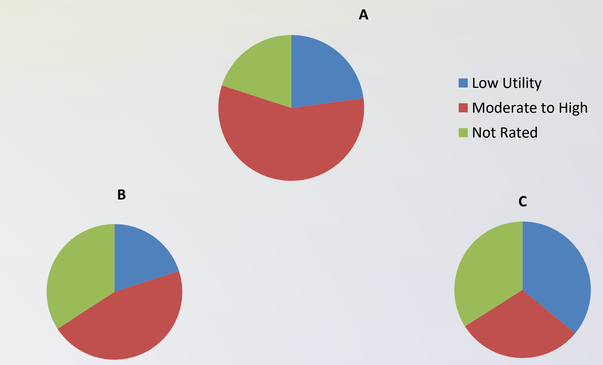
Strategies versus Physics Grade

Question-->	1	2	3 *	4 *	5	6	7	8 *	9	10 *	11 *	12	13	14	15	16
Physics Grade																
A	2	3	4	4	1	1	2	5	0	5	4	2	2	3	3	1
B	1	1	0	2	1	1	1	3	1	3	2	3	1	2	3	1
C	3	2	4	3	1	3	2	1	0	2	2	1	2	2	0	0
Total	6	6	8	9	3	5	5	9	1	10	8	6	5	7	6	2

The most popular strategies overall were also the most popular among "A" students.
* I **read** to learn material
* I **re-read** to learn material
* I **listen** to others talk about course material as a way to learn
* I ask myself **"why" questions** to make connections between new and old material as a way of learning
* I provide my **own explanations** for problems as a way to learn material

Results Continued

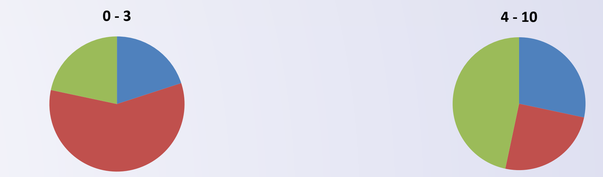
Utility Ratings of Study Strategies of "A", "B" and "C" Students



Percentages

Grade	Low	M-Hi	NR	Tot
A	22.86	57.14	20.00	100
B	20.00	45.83	34.17	100
C	36.00	30.00	34.00	100

Utility Ratings of Study Strategies by Number of Classes Taken



Percentages

Classes	Low	M-Hi	NR	Tot
0 - 3	20.00	58.33	21.67	100
4 - 10	28.33	25.00	46.67	100

Significance of Activity

- We have some preliminary data pointing to the benefits of using moderate to high utility strategies which is consistent with the Dunlosky et al. findings, but our study did not have enough participants to produce statistically significant results.
- Our Strategy Question Number 8 regarding listening to others talk about course material, while not a Dunlosky strategy, was found to generate responses numerically similar to those of the "moderate to high utility" strategies.
- Our results for students with relatively more classroom experience, while counter-intuitive, seem to indicate that they made poorer study strategy choices than their less experienced peers.

Selected References

Bollen, L., Van Kampen, P., Baily, C., & De Cock, M. (2016) Qualitative investigation into students' use of divergence and curl in electromagnetism. *Physical Review Physics Education Research*, 12, 020134. doi: 10.1103/PhysRevPhysEducRes.12.020134

Dioso-Henson, L. (2012). The effect of reciprocal peer tutoring and non-reciprocal peer tutoring on the performance of students in college physics. *Research in Education*, 87(1), 34-49. Retrieved February 14, 2017 from ephost@epnet.com. doi: 10.7227/RIE.87.1.3

Dunlosky, J., Rawson K., March, E., Nathan, M., & Willingham, D. (2013). Improving Students' Learning with Effective Learning Techniques: Promising Directions from Cognitive and Educational Psychology. *Psychological Science in the Public Interest*, 14(1), 4-58. doi: 10.1177/1529100612453266

Kober, N. (2015). Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Redish, E., & Steinberg, R. (1999). Teaching physics: Figuring out what works. *American Institute of Physics*. This article originally appeared in *Physics Today*, 52(January 1999), 24-30.

Stang, J., Barker, M., Perez, S., Ives, J., & Roll, I. (2016) Active learning in pre-class assignments: exploring the use of interactive simulations to enhance reading assignments. *2016 PERC Proceedings* edited by Jones, Ding, and Traxler. Published by American Association of Physics Teachers.

Stefan, M. A. (2010). The customs of independent study of students. *Journal Plus Education/Educatia Plus*. 6(1), 199-205. Retrieved February 14, 2017 from ephost@epnet.com.

White, J., Van Dusen, B., & Roualdes, E. (2016) The impacts of learning assistants on student learning of physics. *2016 PERC Proceedings*, edited by Jones, Ding, and Traxler, published by American Association of Physics Teachers.

Zlateva, G. & Tsankova, E. (2009). Application of innovative methods to optimize the learning process in physics for medical students. *AIP Conference Proceedings*. 1/21/2010, 1203(1), 1298-1301. Retrieved February 14, 2017 from ephost@epnet.com. doi: 10.1063/1.3322359